U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Building Energy Data Sub-Program

Monday, April 15, 2019

Harry Bergmann
Data Infrastructure Fellow, Emerging Technologies

Schedule

- 11:30-12:00 – Introduction to Portfolio
- 12:00-12:30 – Overview of Standards & related efforts
- 12:30-1:30 – Lunch
- 1:30-2:15 – Overview of Management & Analysis tools
- 2:15-3:00 – Unstructured Data
- 3:00-3:30 – Discussion & Questions
- 3:30-4:00 – Break
- 4:00-4:45 – Asset Score
- 4:45-5:30 – Home Energy Score
- 5:30-6:00 – Wrap up & Discussion (REVIEWERS ONLY)

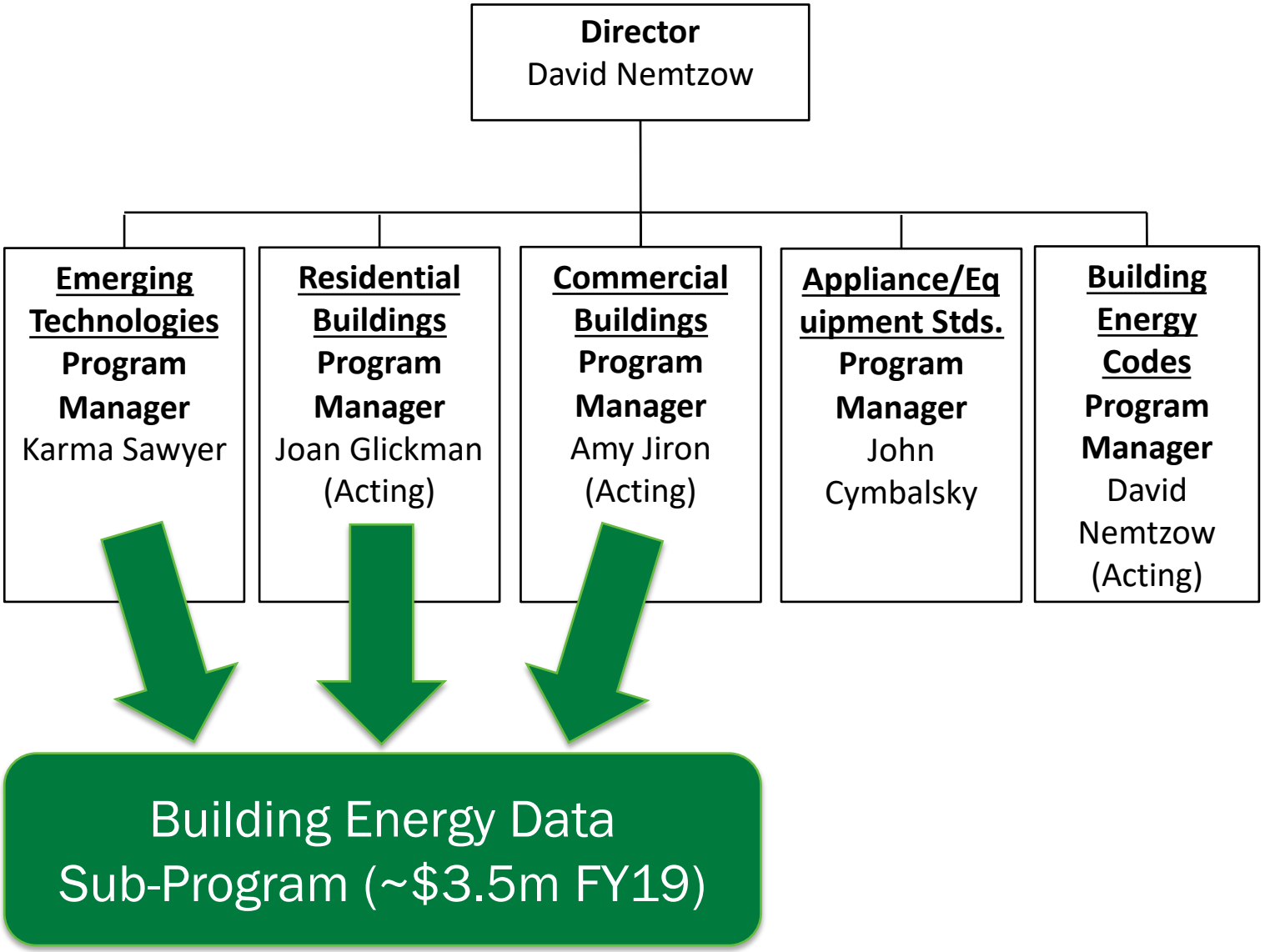
Overview of the Day

- **Part 1: Program Overview (11:30 – 11:50)**
  - BTO's View of the Market & Portfolio Criteria Overview
- **Part 2: Standardization (11:50 – 12:30)**
  - BEDES, BuildingSync/HPXML, UBID, Brick
- **Lunch (12:30 – 1:30)**
- **Part 3: Tools & Analytics(1:30 – 2:15)**
  - SEED, Audit Template/Asset Score, BPD, EDV
- **Part 4: Future Direction & Investments (2:15 – 3:00)**
  - AirBEM, Unstructured Data
  - Increasing velocity of data generated

Who am I?

- **B.A. in Geography with GIS minor** – GWU
- **Master in Environmental Science & Management** – Bren School, UC Santa Barbara
  - Thesis: Developed a business model around EE & water improvements for low income multifamily housing.
- **Southern California Regional Energy Network Project Manager** – The Energy Coalition
  - Worked with local public agencies providing turnkey energy efficiency project delivery services.
- **Data Infrastructure Fellow** – Building Technologies Office

What are we talking about?



Mission & Goals of the BED Sub-Program

Vision

- Data serves as the starting point for working toward a more efficient, equitable, affordable, and resilient built environment.

Mission

- To provide a freely available network of tools and resources, built upon standards, that enable the fluid exchange of building energy and attribute data in order to better achieve energy efficiency savings in the built environment.

Goals

- Develop a network of interoperable tools on which the private sector can build specialized services.
- Collaborate with stakeholders to produce easily-adopted standards and exchange specifications to promote interoperability.
- Deliver products which enable planners, owners/investors, utilities, regulators, and others to make better informed strategic decisions.

What to Watch For:

- **Scope: Does our area of work make sense for BTO?**
- **Impact: How much of the market are we affecting?**
  - Working across commercial & residential, major state & local governments
- **Coordination & Collaboration: How well are we engaging with stakeholders?**
  - Industry partnerships, government, non-profit, etc.
- **Metrics: Are we showing appropriate improvement and growth rates?**
  - Adoption is increasing, usership is growing alongside market penetration
  - Tools are incorporated into programs and policies at an accelerating rate

Part I: Introduction & Strategic Overview

The Market Through BTO's Eyes

Part I: Agenda

Some definitions and examples

- Modeled vs. measured, etc.
- Use cases for different types of data

Issues

- Availability
- Standardization
- Provenance

Role of government

Current and future program

Ground Rules: Data is *measured*, not modeled.

Measured data

- Observations
- Use cases: benchmarking, inputs for modeling (black box or white box)
- Issues: collection, “quality”, provenance, privacy, standards

Not dealing with modeled “data”, i.e., modeling outputs

- Measured data + assumptions + calculations
- Use cases: what-if analysis (optimization, planning), normalized calculations (codes, ratings)

Types of Data

"Static" (relative to use case) → typically interpreted as assets/operations

- High-level – location, use-type, floor area, system type, operating hours, setpoints
- Detailed – geometry, constructions, equipment, lighting, schedules, sequences
- "fixed" for analytical purposes → can be a time series, can be stochastic

"Dynamic" (relative to the use case)

- Energy use
- Indoor/outdoor conditions – temperature, humidity, lighting levels, CO2, air-quality, wind, solar, etc.
- Momentary system state – equipment on/off/PLR
- Other relevant variables – occupancy, occupant behavior, etc.
- (Raw) time series or aggregation/reduction

Temporal resolution

- Granularity/frequency: instantaneous → 30-sec → 15-min → hr → day → month → year
- Range/duration (> granularity)

Spatial Resolution

Applicable to both static and dynamic data

"Building" – is there an unambiguous definition?

Smaller than a building

- Tenant Suite → Zone → Circuit/Space → Occupant/Person → Sensor/Control-Point
- End-use System → Sub-system/component → Sensor/Control-Point
- Same granularity/range concepts as temporal resolution

Bigger than a building

- District → City → State → Region → Country
- Portfolio – may or may not be geographically contiguous or connected by systems

Some things (e.g., meter) can be both bigger or smaller than a building

How small or big makes sense?

Example Applications & Use Cases

ESPM & BPD → benchmarking

- Country: Building → [HL assets, HL operations, annual energy-use]
- Spatial range: spatial granularity → [data descriptors]

BayREN BRICR → retrofit program-planning, screening

- City: Building → [HL assets, HL operations, monthly energy-use]

Asset Score → rating, retrofit recommendations

- Building: Building → [detailed assets]

Qcoefficient → MPC

- Building: Subsystem → [detailed assets, 15-min energy-use, 15-min zone-conditions]

URBANopt → district master-planning, district system design

- District: Building → [HL assets, HL operations, 15-min energy-use]

Which use-cases are most important to DOE?

Issue: Collection & Availability

	Public		Private				
	ESPM BPD	SEED	Audit	BAS	SEED	AMI GButton	SubMeter
High-level asset/operation	Y	Y					
Detailed asset/operation			Y		Y		
Annual/Monthly Energy Use	Y	Y	Y				
15-min Energy Use						Y	Y
15-min Subsystem Energy Use							Y
15-min HVAC State/Zone Temp				Y			

What data is collected? What applications does it support?

Publicly available data is mostly high-level asset/ops & annual/monthly energy use

- Applications limited to benchmarking & screening

Higher-resolution data must be manually collected & fused

- Some private-sector platforms, e.g., Lucid BuildingOS

Issue: Standardization

Dictionaries

- Names for terms, values and temporal/spatial aggregations/reductions
- Examples: BEDES (building elements), Haystack (sensor/control “points”)

Schema and model views

- Structure and relationships
- Examples: HPXML, BuildingSync, IFC/BIM, gbXML, Brick, CityGML, EnergyADE
- Minimal requirements for specific use cases
- Dictionary : Schema :: BEDES : BuildingSync

Indices

- How do find/match a record in a database?
- Examples: address, Lat/Long, UBID

Issue: Provenance & Provenance

Upstream – quality ← where did this data come from?

- How accurate is it? How complete? How frequently updated?
- Is it self-reported? Is it curated? Are there QA practices or measures?

Downstream – terms of use/privacy ← who is allowed to do what with this data?

- Are there restrictions on use? Publication? Redistribution?
- Are there anonymization/privacy measures?
- Can the data be matched/mashed with other data?
- Sensitivities & PII? Mosaic Issue?

Role of Government

Which issues are most significant – availability, standardization, or provenance?

- Where can government play a meaningful and proper role?

1. Standardization

- Clear need, market clamoring for solutions
- Traditional role for government or similar, no competition with private-sector
- Supports the greatest number of use cases → biggest bang for buck

2. Collection & upstream provenance

- Open-source standard-compliant tools for reliable/accurate data collection (for some kinds of data)
- For some kinds of data and use-cases → avoid private-sector competition
- Data collection → availability → standard-compliance → uses → more data collection (virtuous cycle)

3. Publication & downstream provenance

- Very limited activity here → emphasis on supporting research use & protecting privacy
- Perhaps encourage others to publish data, but not mandate or do it for them

Discussion

Until 12:00

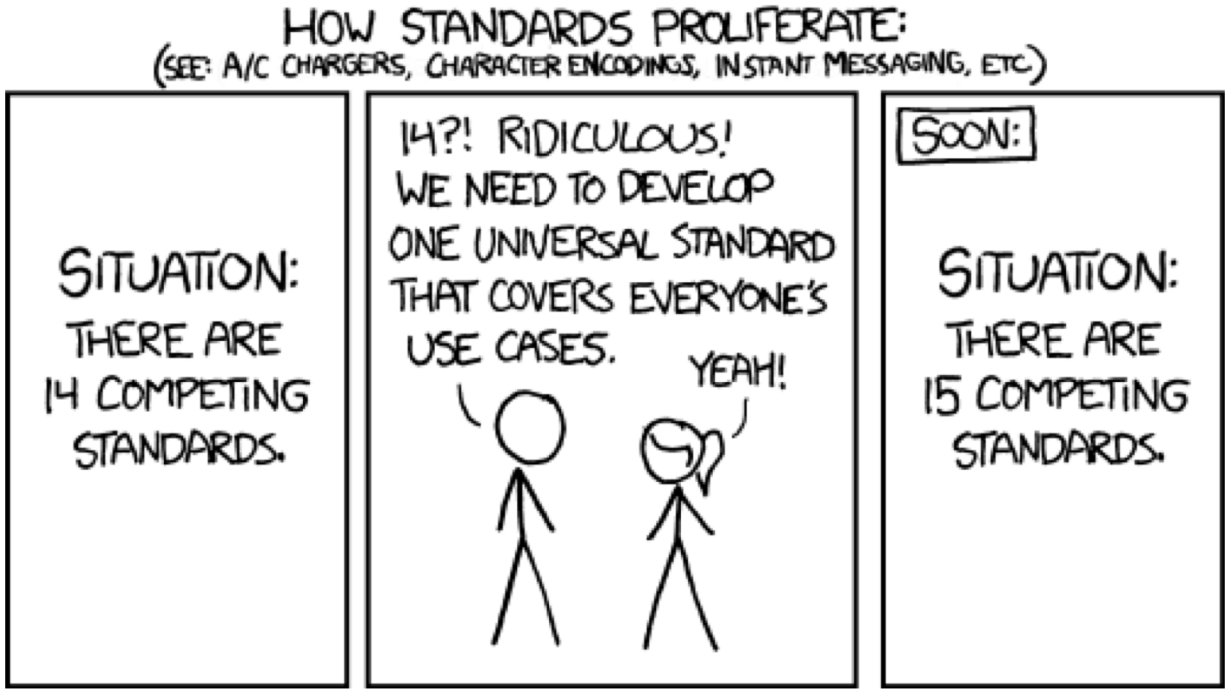
Part II: Standardization

Reducing Transaction Costs and Increasing Accessibility

Part II: Agenda

- BEDES
- BuildingSync/HPXML
- UBID

Standardization Strategy



Critical Elements of Standardization

BEDES
BUILDING ENERGY DATA EXCHANGE SPECIFICATION

BUILDING SYNC
U.S. DEPARTMENT OF ENERGY

Dictionary of Terms & Fields

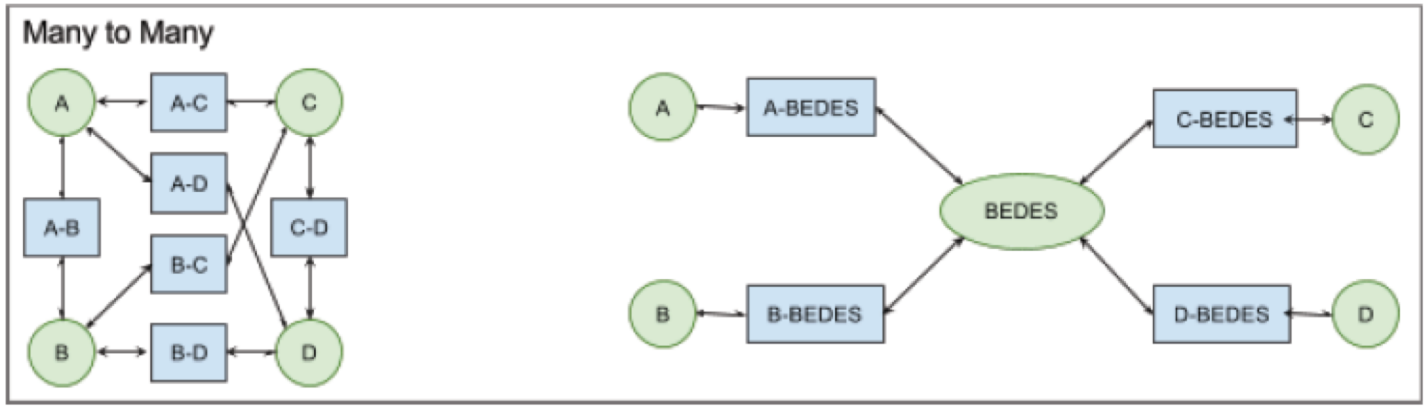
Schema to manage relationships

Index to identify records

Dictionary: BEDES

BEDES is a collection of terms and definitions *designed to facilitate the sharing of building characteristics and energy data among data collection and analysis tools/activities more easily, consistently, and at lower cost.*

Use BEDES as a “rosetta stone” to merge and exchange data across disparate datasets, e.g. property database, energy data, O&M data, etc.



bedes.lbl.gov

BEDES
BUILDING ENERGY DATA EXCHANGE SPECIFICATION

BEDES Adoption

Over 30 organizations and applications have initiated or completed BEDES compliance

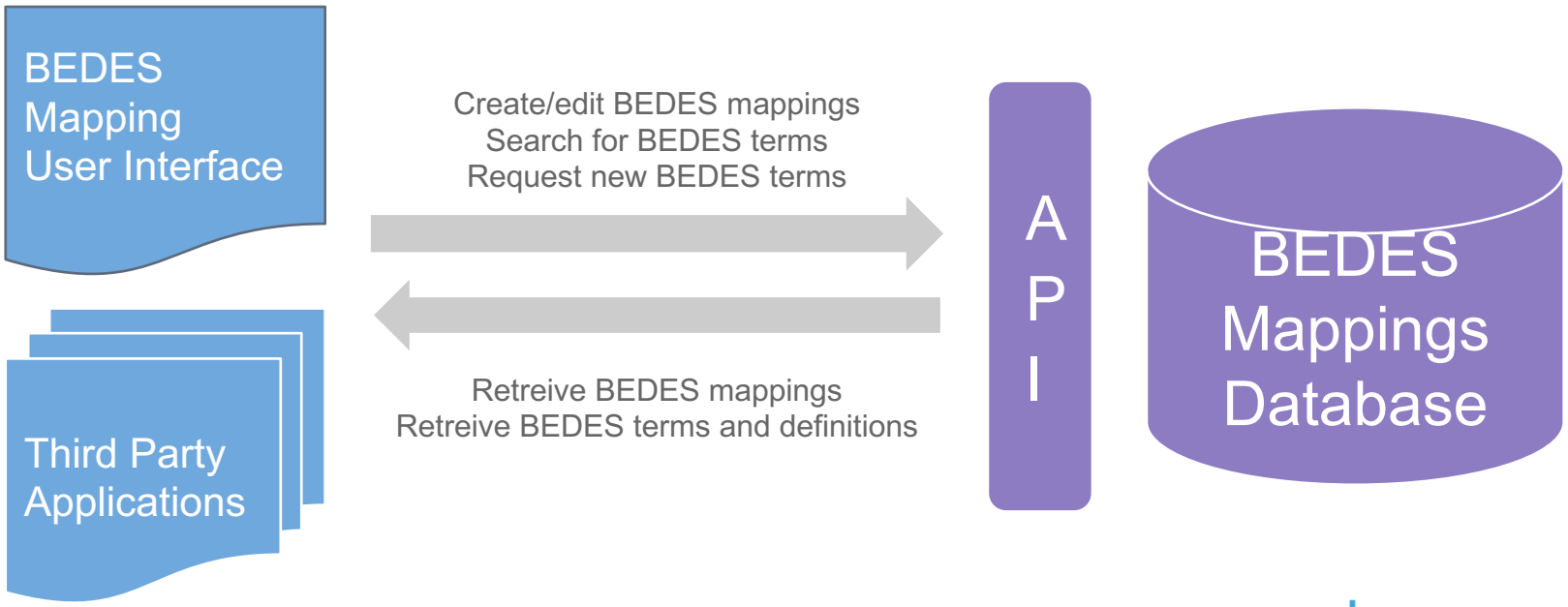
BEDES Compliance

- Publish mapping
- Use BEDES in data import/ export templates
- Use BEDES for multi-application data exchange

BEDES
BUILDING ENERGY DATA EXCHANGE SPECIFICATION

Coming Soon: BEDES Mapping Manager

An open-source tool to develop, maintain and use BEDES mappings

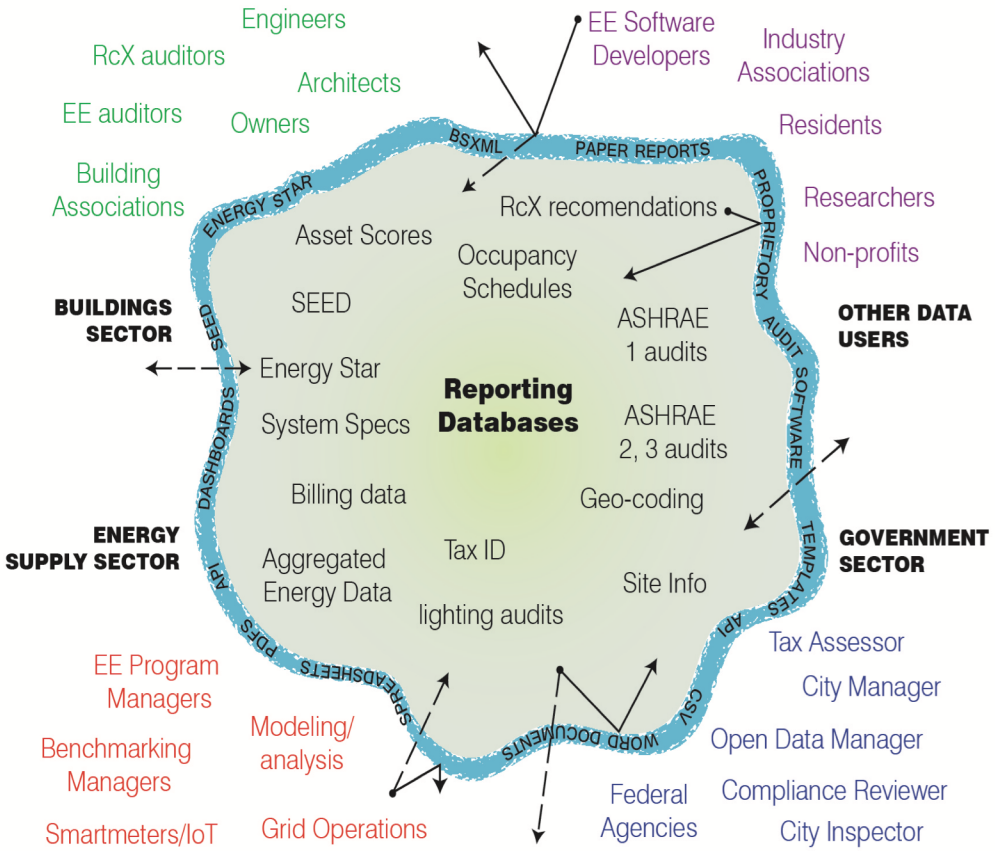


BEDES
BUILDING ENERGY DATA EXCHANGE SPECIFICATION

BuildingSync: Barriers

Problem Statement:

There are many consumers of commercial building data, including auditors, engineers, designers, operators, inspectors, researchers, etc. The data are typically provided in *varying formats* with *varying definitions*. This lack of standardization limits the data's usefulness.

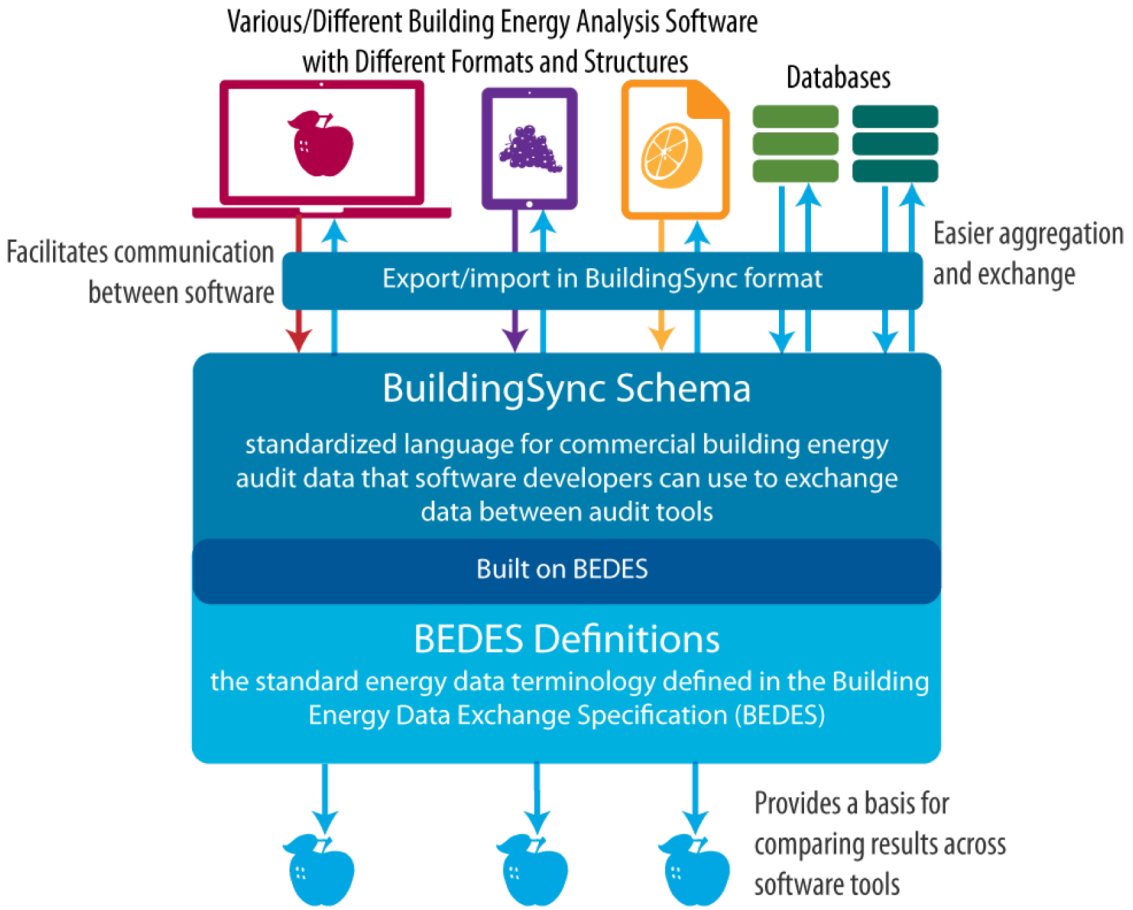


Credit: Amanda Lloyd, CBEI

BUILDING SYNC
U.S. DEPARTMENT OF ENERGY

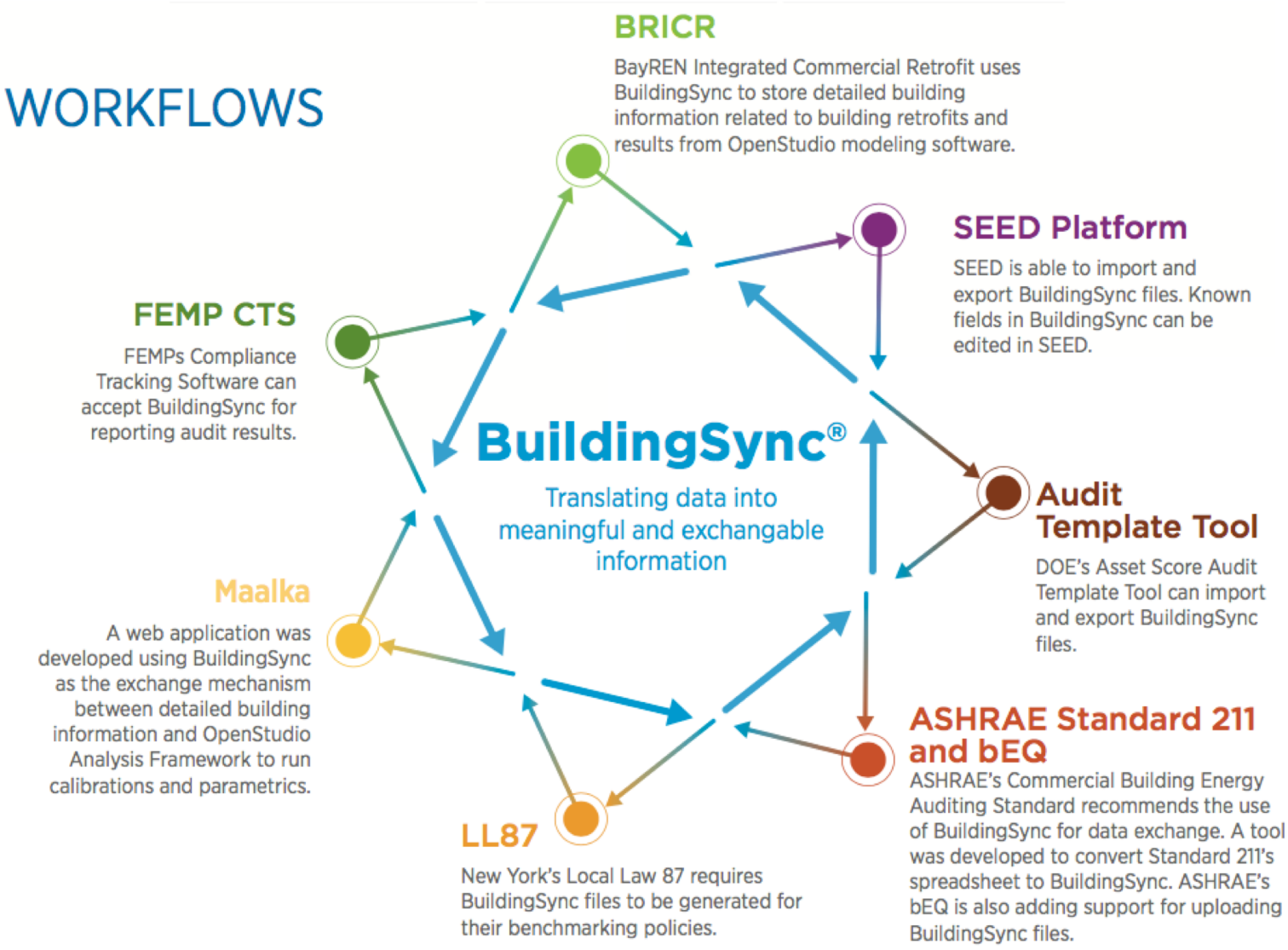
What is BuildingSync?

- A common file format for energy audit data to streamline reporting and data transfer
- Directed by DOE and developed by NREL
- Built on Building Energy Data Exchange Specification (BEDES)
- Covers ASHRAE Standard 211 audit levels, bEQ
- ASHRAE TC 7.6 – Building Data Exchange



BUILDING SYNC
U.S. DEPARTMENT OF ENERGY

BuildingSync: Adoption

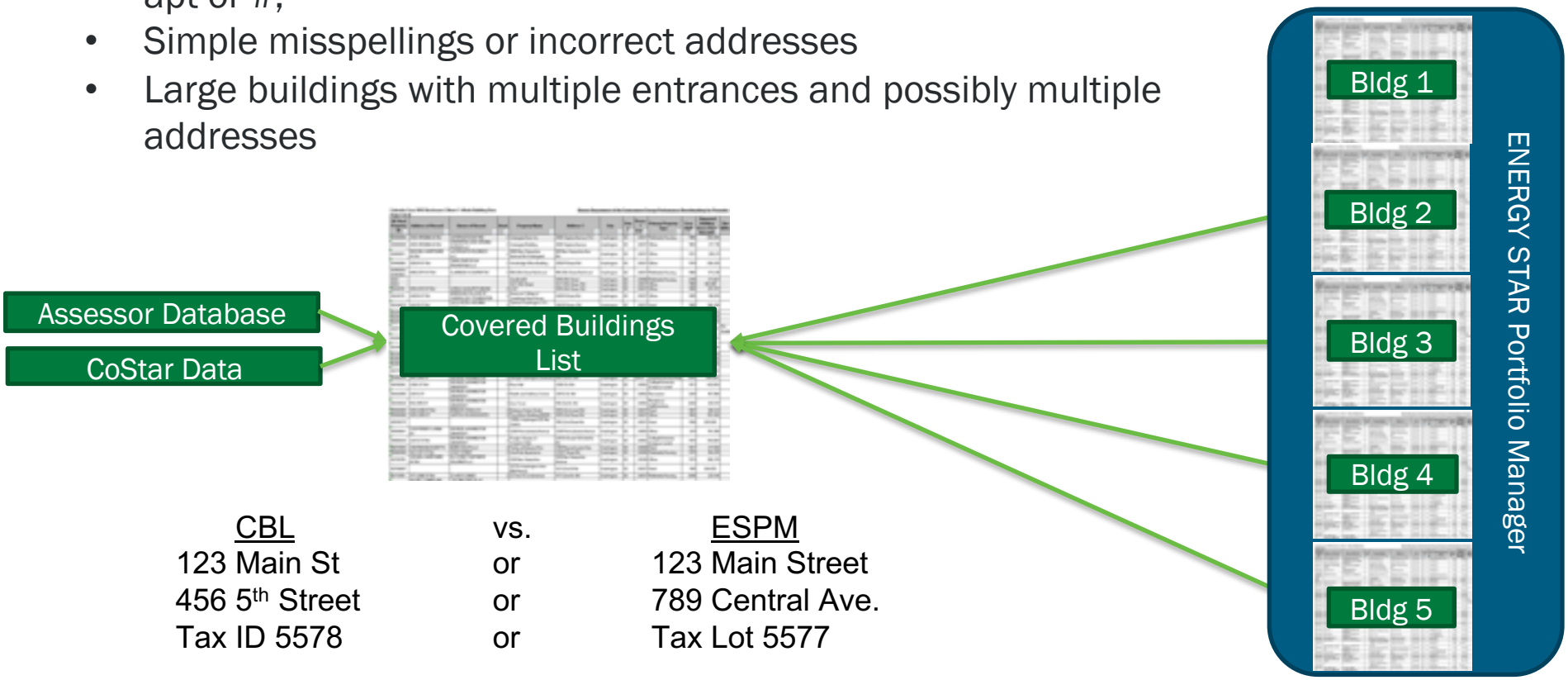


Unique Building Identification

The lack of a standardized way to identify buildings makes it difficult to accurately associate data with a specific facility, creating a barrier to effective asset management, research, and analysis.

Where the current address system breaks down:

- Different address abbreviation, e.g., st or street; ave or avenue; apt or #;
- Simple misspellings or incorrect addresses
- Large buildings with multiple entrances and possibly multiple addresses



CBL	vs.	ESPM
123 Main St	or	123 Main Street
456 5th Street	or	789 Central Ave.
Tax ID 5578	or	Tax Lot 5577

Unique Building Identification

Grid Reference System


Grid reference systems identify locations using Cartesian coordinates to delineate regions of the map. UBID uses Open Location Code by Google Zürich (http://plus.codes) to identify the location of the center of mass of a shape.

UBID Methodology

1. Determine shape of footprint.
2. Calculate center of mass of shape.
3. Identify grid cell that contains center of mass of shape.
4. Measure extent of bounding box for shape using grid cell.
5. Write UBID string: 87C4VW7W+JWH-12-15-9-9

Unique Building Identification

Building Energy Data Analysis Accelerator

- Launched at 2018 Better Buildings Summit
- Goal: field validation for UBIDs; identify and create solutions for implementation barriers; quantify benefits in terms of energy saved, program efficacy, and operational benefits.

Pilot Partners:

Association for Energy Affordability	**California Energy Commission**	**Commercial Real Estate Data Alliance (CREDA)**
District of Columbia	**Institute for Market Transformation**	**Miami-Dade County, FL**
Saint Paul, Minnesota	**San Francisco, CA**	**San Jose, CA**
U.S. Environmental Protection Agency (EPA)	**U.S. Green Building Council**	**Telecommunication Industry Association (TIA)**

Discussion

Until 12:30

Lunch

Reconvene at 1:30

Part III: Tools & Analytics

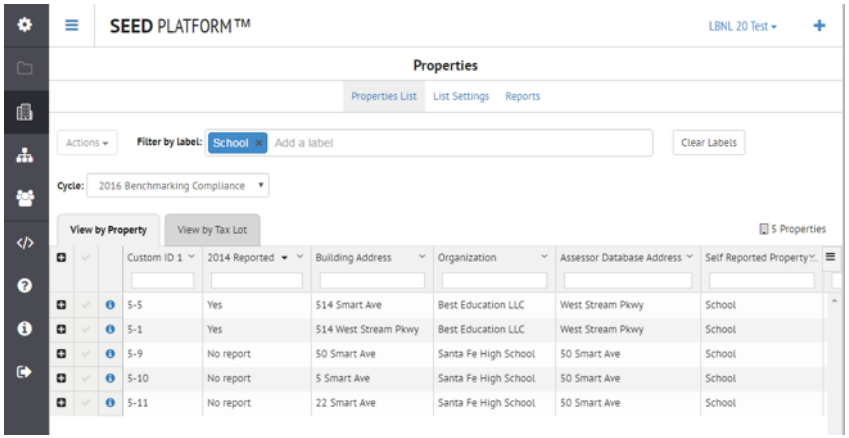
Turning Data into Information

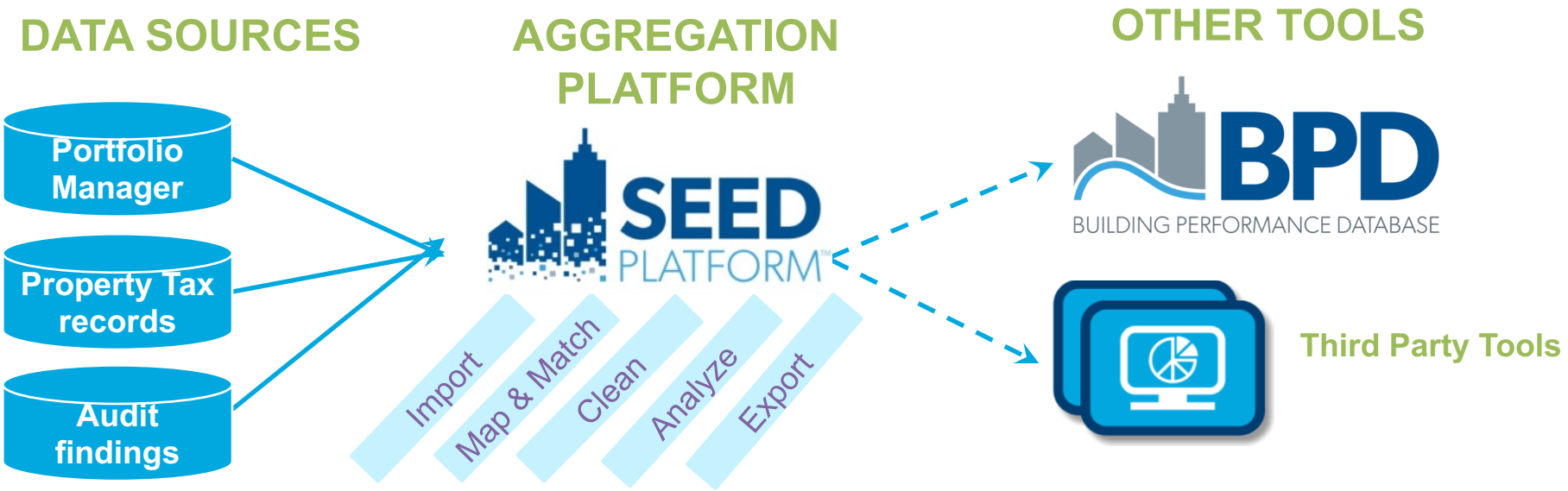
Part III: Agenda

- SEED
- Audit Template/Asset Score
- Building Performance Database (BPD)
- Energy Data Vault (EDV)

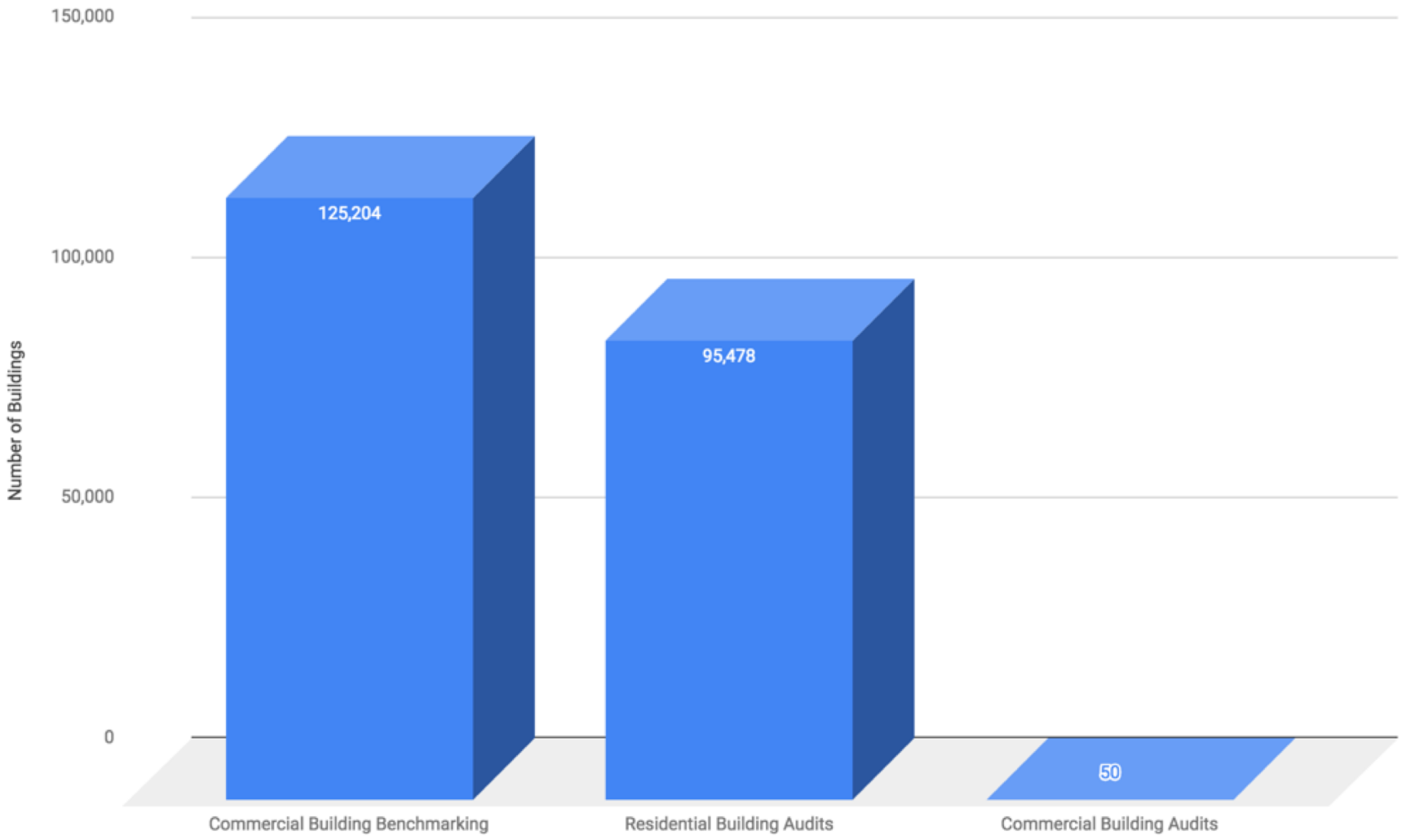
SEED Platform

- Open source database for building energy & attribute data
- Data management back-end hub for BTO tools portfolio

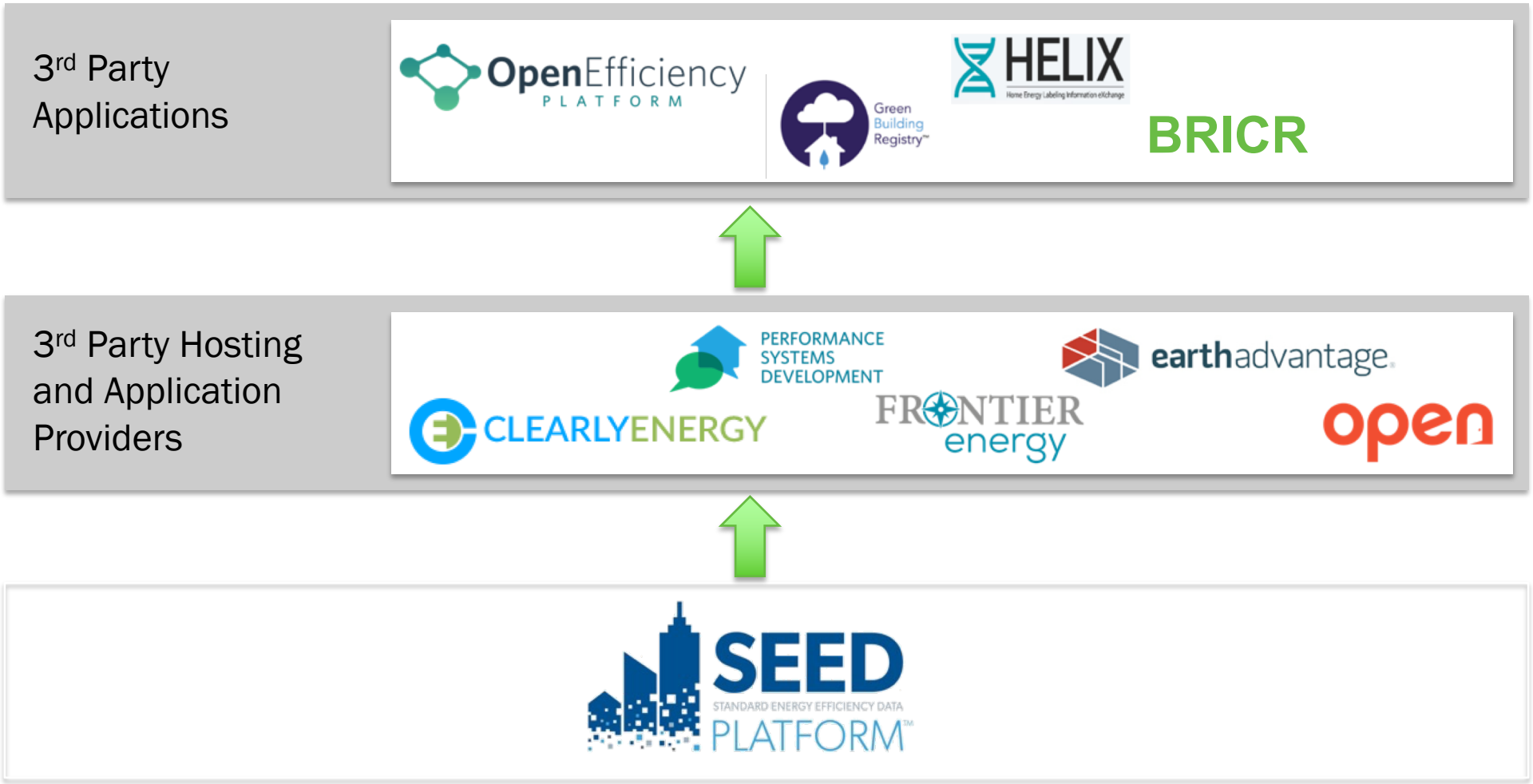




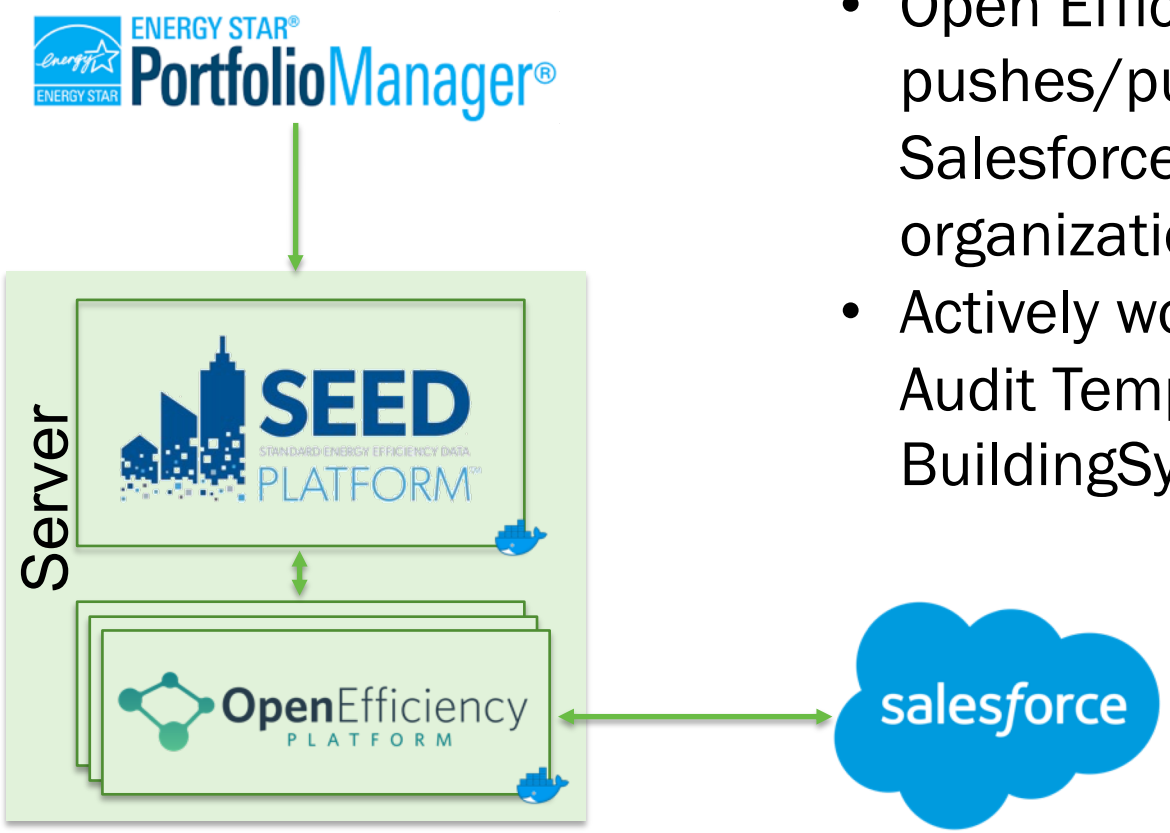
SEED Platform as a Platform



SEED Platform as a Platform



SEED Platform as a Platform: City of SF



- SEED pull data from Portfolio Manager
- User manages records in SEED
- Open Efficiency Platform pushes/pulls data from Salesforce for each organization
- Actively working on connecting Audit Template data using BuildingSync

Audit Template

- **Standardizing inputs and outputs**
  - Align with new development of industry standard (ASHRAE Standard for Commercial Building Energy Audits)

- **Leverage built-in capability for data quality control**
  - Automating error checking
  - Verifying required fields
  - Easy access to previously entered audit reports
  - Easy sharing and transferring building records

- **Seamless data transfer to other tools**
  - Integration of BuildingSync XML allows for seamless data transfer (SEED, third-party tools)

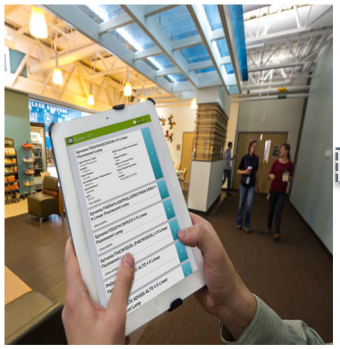
ASHRAE Level 2 Input

BUILDING ENERGY ASSET SCORE AUDIT TEMPLATE

U.S. DEPARTMENT OF ENERGY

Other Tools

Audit Template



Private Sector Energy Efficiency Tools and Programs

BUILDING ENERGY ASSET SCORE AUDIT TEMPLATE
U.S. DEPARTMENT OF ENERGY

Input Mode

Database

CSV
PDF
BX XML

City Dashboard

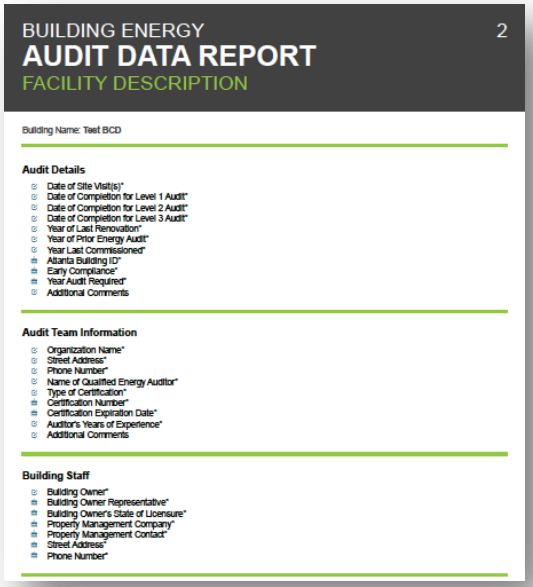
SEED PLATFORM
STANDARD ENERGY EFFICIENCY DATA
U.S. DEPARTMENT OF ENERGY

Auditors

1. Choose City Template
2. Perform Audit
3. Submit

City Admins

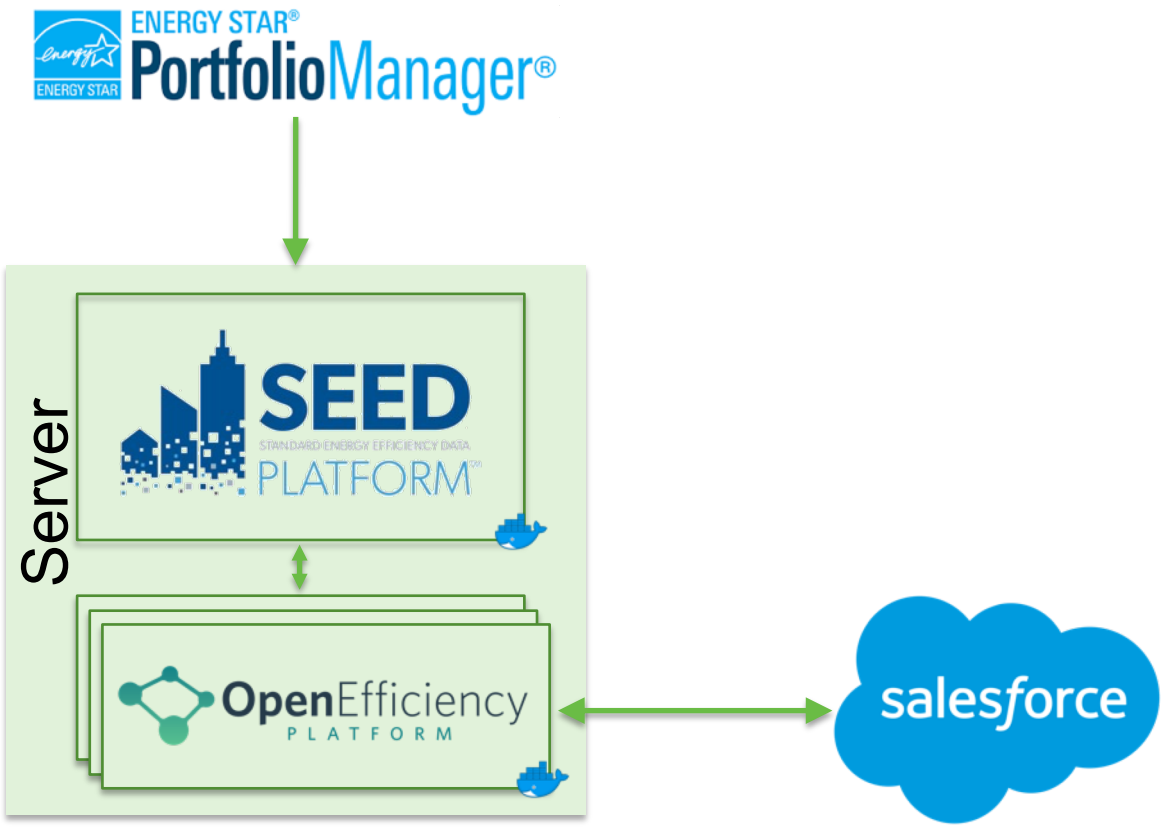
Mark Compliance
Download Reports
Track Progress



Existing templates:

New York City (official)
San Francisco (official)
Atlanta (official)
Los Angelus (pilot in June)
BRICR (ongoing)
ASHRAE Level 2

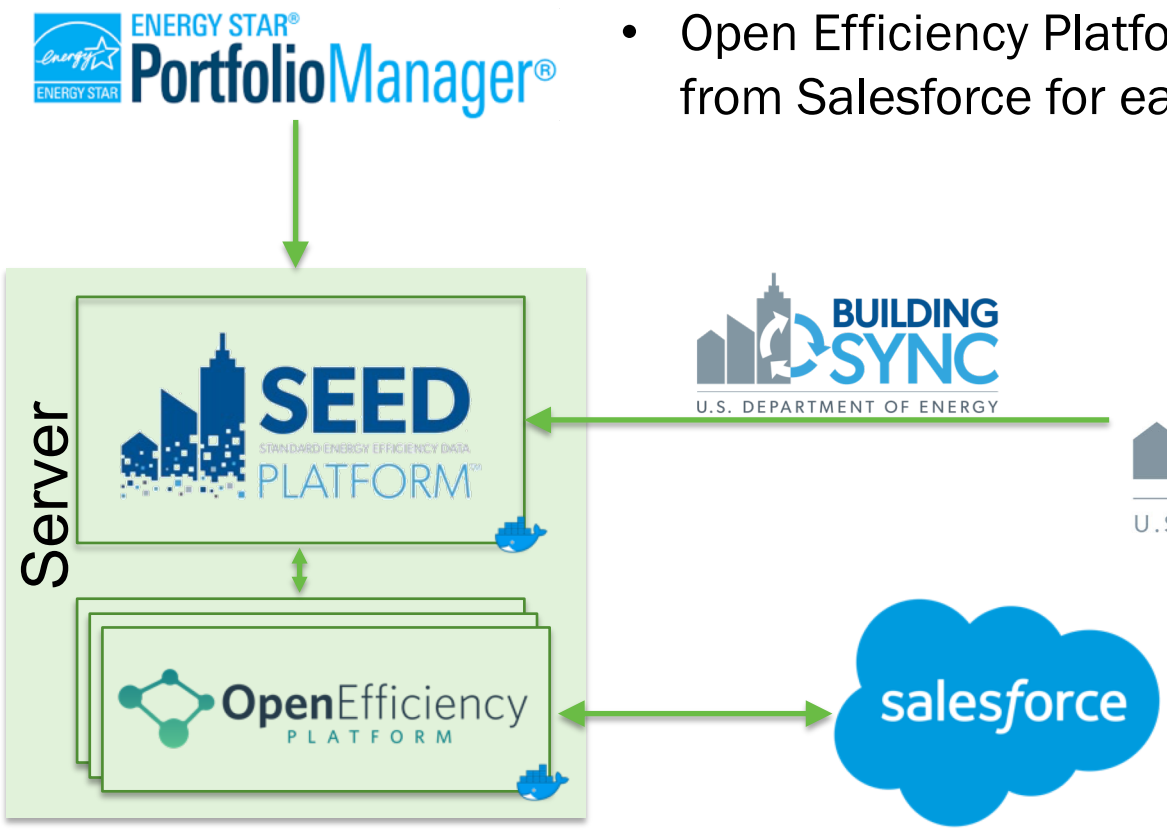
SEED Platform as a Platform: City of SF



SEED Platform as a Platform: City of SF

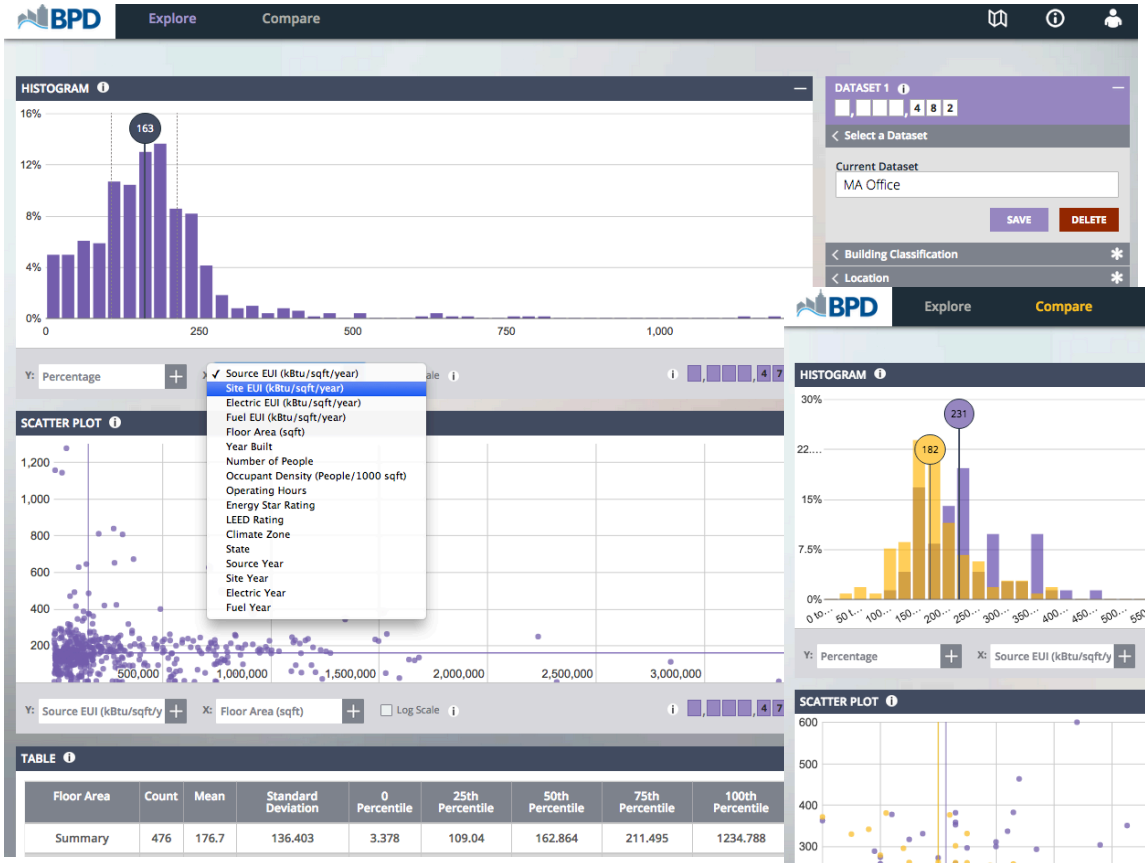
Incorporating the Audit Data workflow

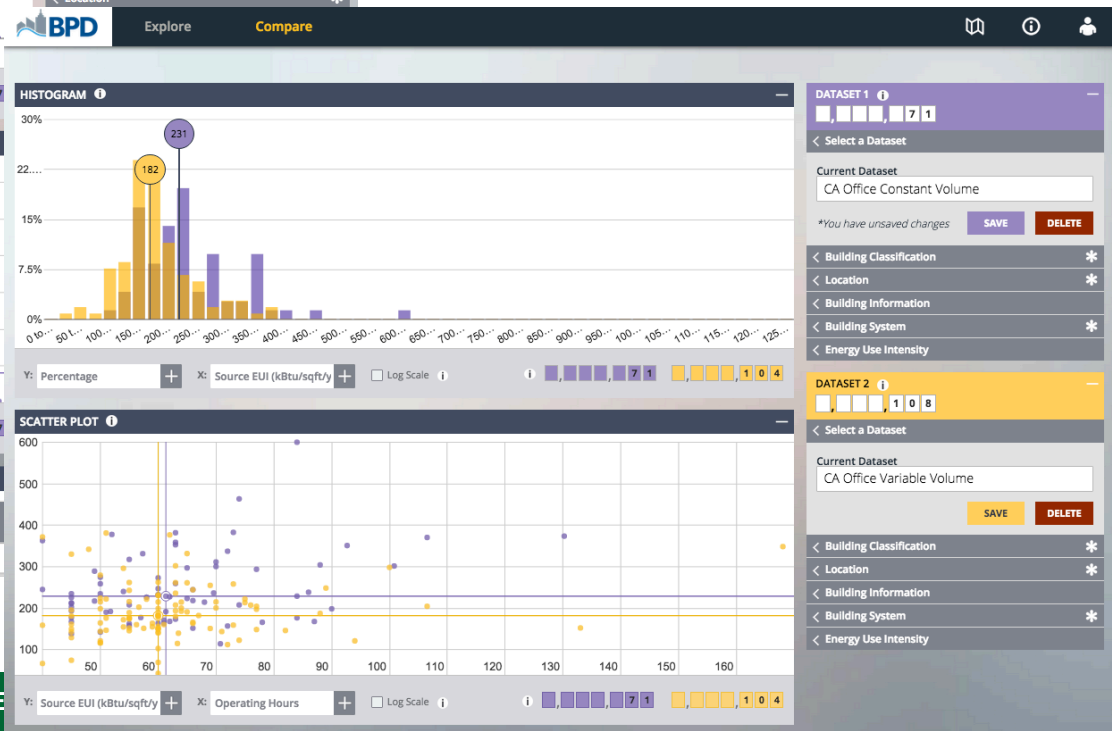
- User manages records in SEED – can merge benchmarking data from ESPM with BuildingSync files in one place
- Open Efficiency Platform pushes/pulls data from Salesforce for each organization



Building Performance Database

- The nation's largest publicly-accessible dataset of information about the physical and operational characteristics of real buildings.
- Use BPD to compare your building's energy performance to customized peer groups

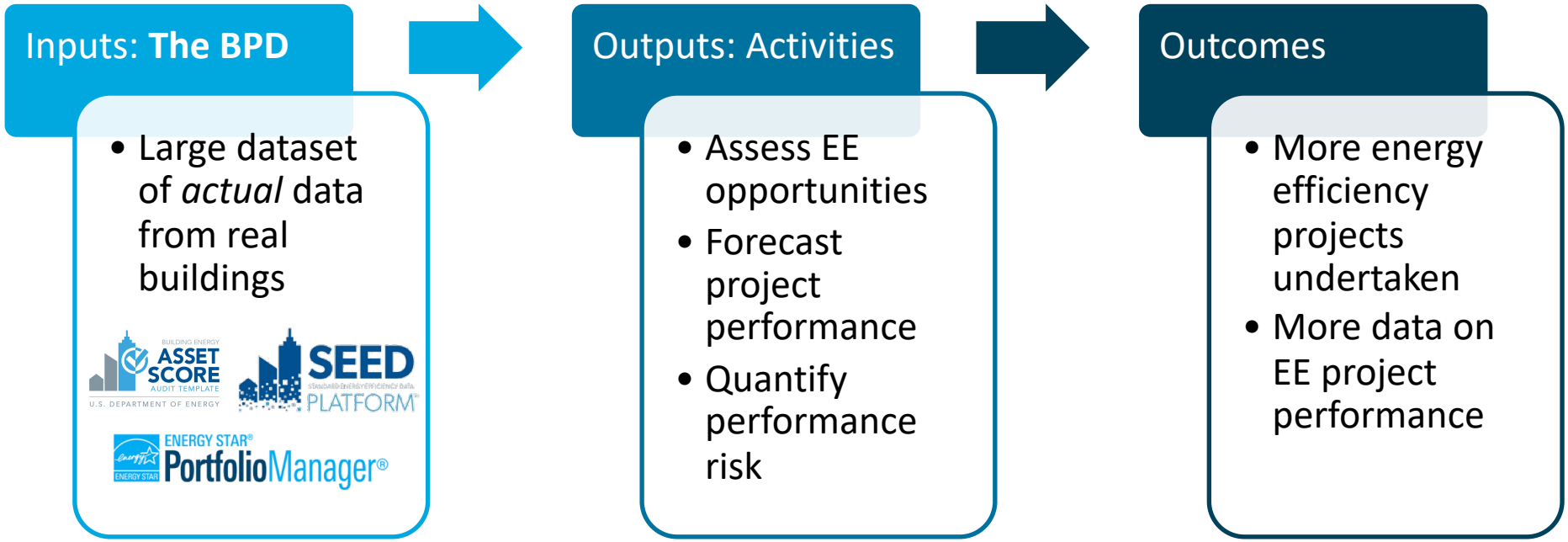




Over
1 Million
buildings

bpd.lbl.gov

BPD Makes Data Available to a Broad Audience



Value for decision-makers (e.g., building owners, policy makers, service providers, financial and research institutions, utilities, program administrators):

Analyze peer groups defined by geography or building-specific factors

- Regional markets
- Specific building or equipment types
- Range of energy use intensities

BPD Users

Analysis tool

- > 13,000 unique users since inception
- ~100-150 user sessions per week
- Referenced in ASHRAE 211 Standard for commercial building audits
- Referenced in ASTM draft standard for property condition assessments

API licensees

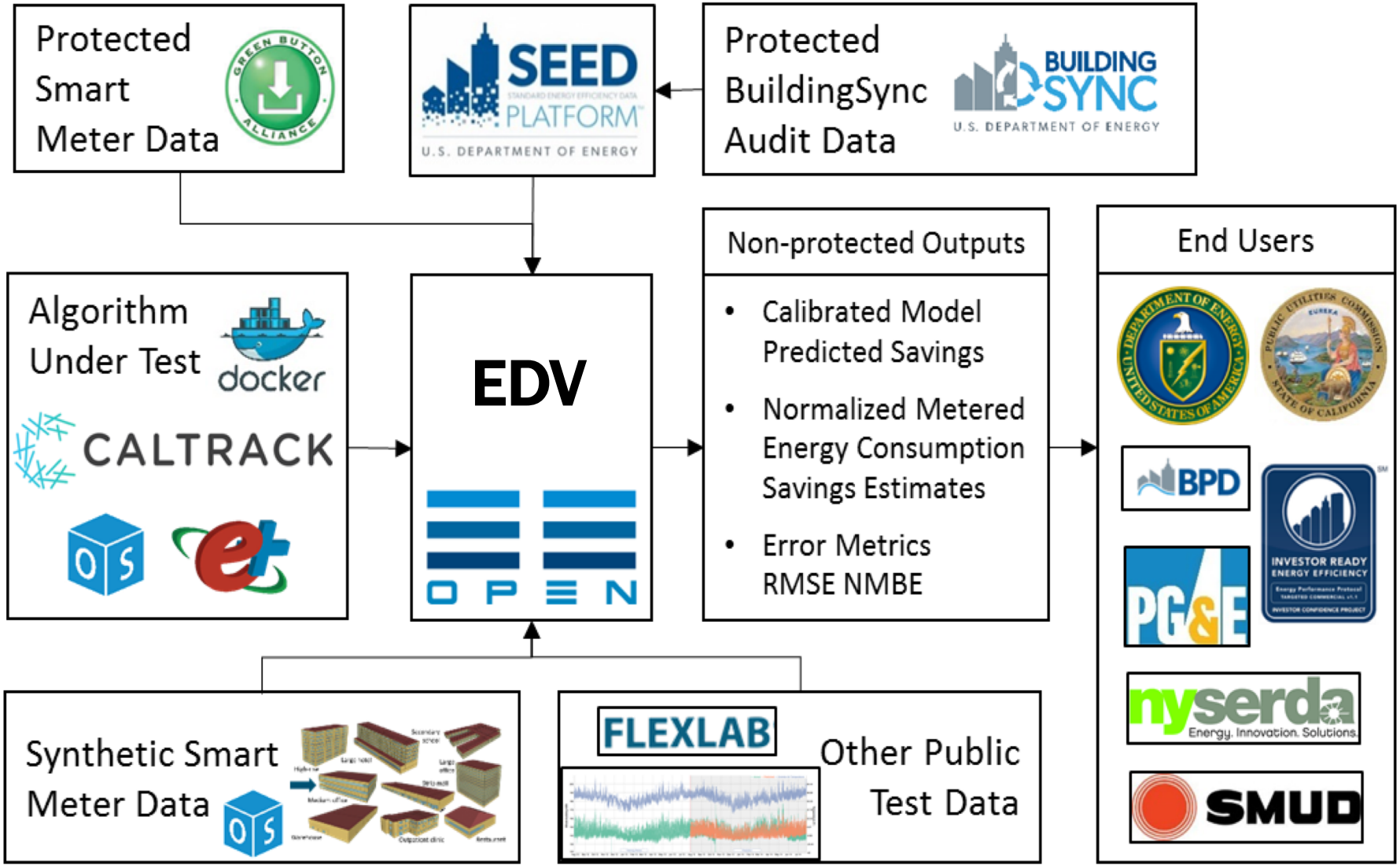
>60 API licensees

kevala
energyacuity
energywatch
energy economics simplified
lucid
RUTGERS
the Energy Coalition
U.S. ENERGY ENGINEERS
NYIT
ProKarma

Energy Data Vault

- **Customer energy data (particularly 15 minute data) is very sensitive, utilities guard it closely**
- **Need to evaluate performance and design, test, and compare new algorithms**
- **EDV will investigate:**
  - New privacy protection models to enable energy data access without needing explicit customer consent due to protection of PII
  - Synthetic smart meter data to evaluate algorithms
    - Energy savings calculations, non-routine adjustments, non-routine event detection, outlier rejection
  - Provide a standard environment for researchers to develop, test, and deploy algorithms
    - Connect to public/non-protected test data-sets for development
    - Connect to private/protected data-sets for operational deployment

Energy Data Vault



Discussion

Until 2:15

Part IV: Future Direction & Investments

BED Subprogram Roadmap

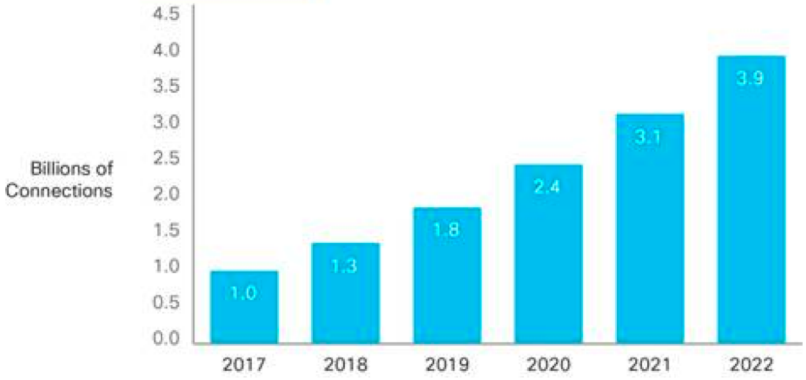
Part IV: Agenda

- **Consideration of Market Movement**
  - New tech, risks, and a lot more data
- **New FY18/19 Investments**
  - Brick Schema
  - AirBEM
  - Unstructured Data

Market Movement

- **New technologies are emerging:** AI, ML, Blockchain, etc.
- **High-level risks:** Cybersecurity & Privacy
- **New data being generated:**
  - MELs
  - "Internet of Things"
  - Increasing M2M connections
    - 32% CAGR (2017-22)

Global Machine-to-Machine Growth
(*Source: Cisco VNI Mobile 2019)*



- **New market actors:**
  - When your home can be controlled by your Alexa, or your Nest, what does that mean for utility demand response programs?

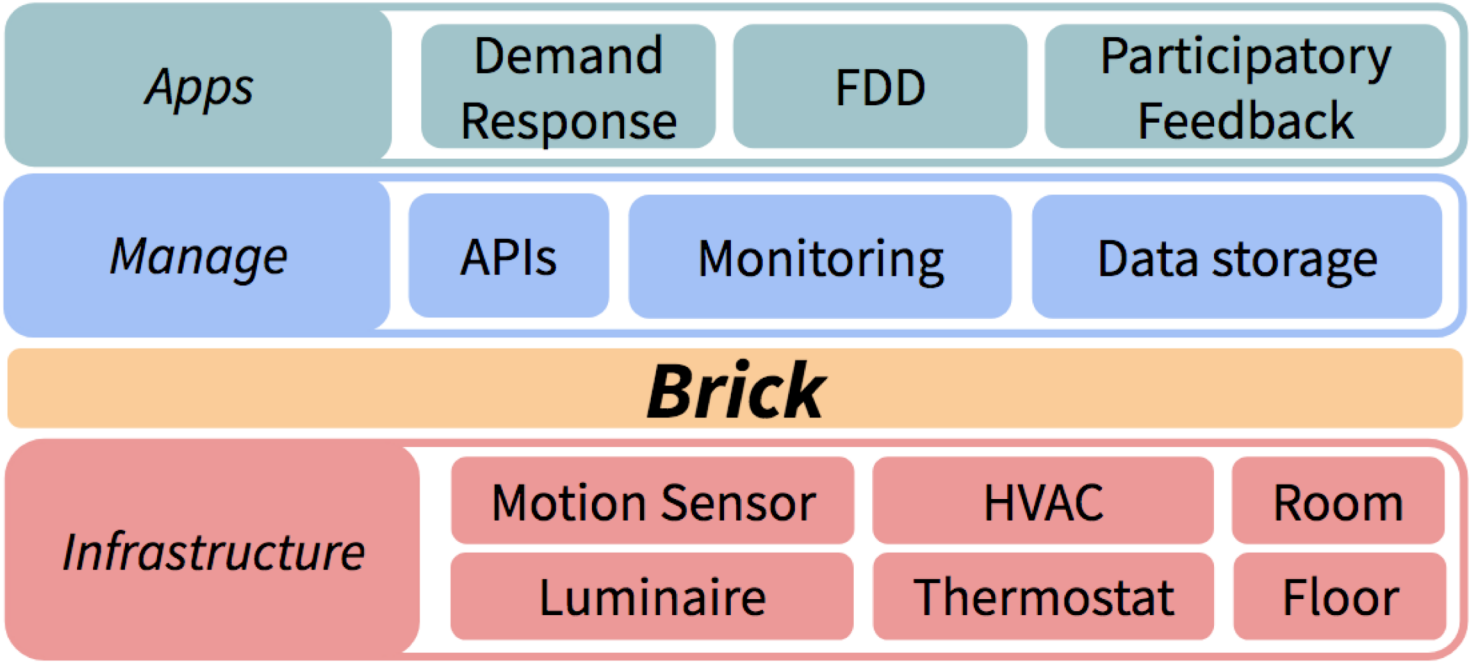
Role for BTO

Given Market Movement, BTO will focus on:

- Continued work on Standardization
- Interoperability *(Session Tuesday at 2:30)*
- Miscellaneous Energy Loads (Session Tuesday at 2:00)
- Leveraging new & unstructured data sources
- Data to enable grid-interactive efficient buildings (GEB)

Brick Schema + Structured Metadata

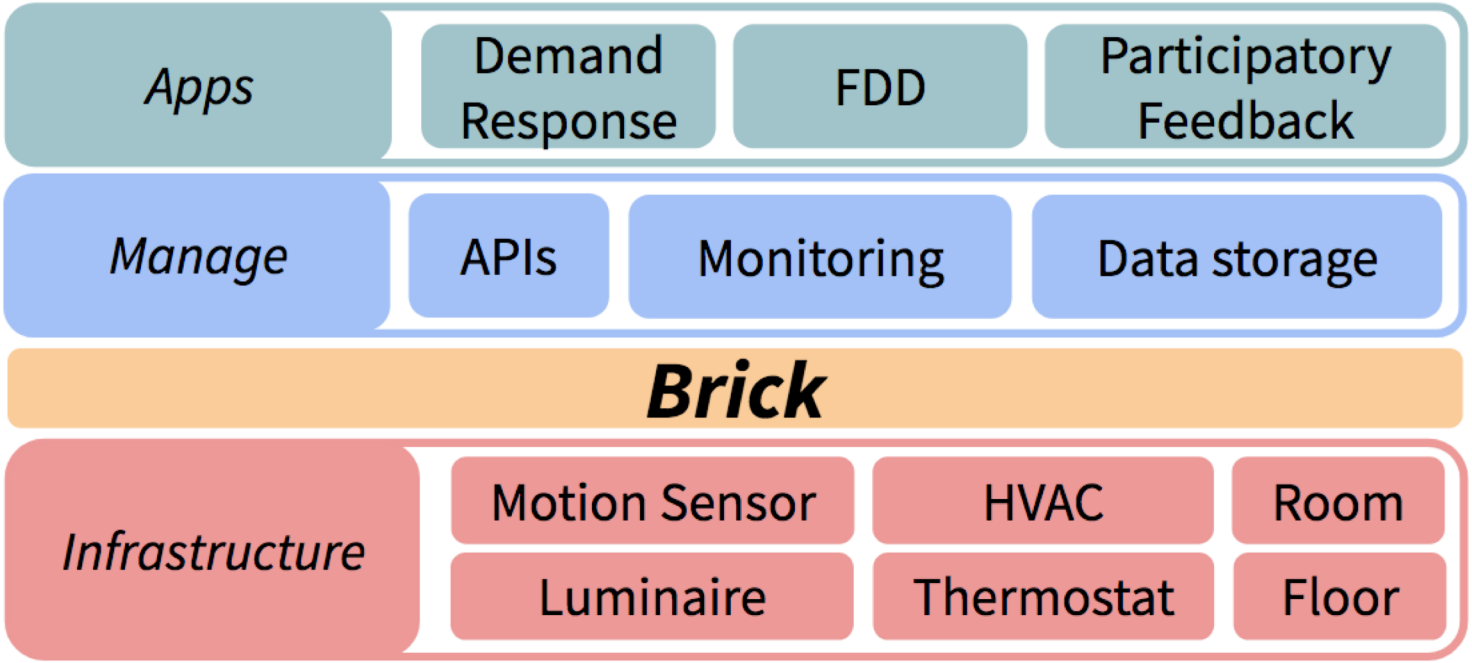
(Feb. 28, 2018) – The ASHRAE BACnet committee, Project Haystack and the Brick initiative announced they are actively collaborating to integrate Haystack tagging and Brick data modeling concepts into the new proposed ASHRAE Standard 223P for semantic tagging of building data.



Brick Schema + Structured Metadata

Goal: “Succeed fast” in the controls space by:

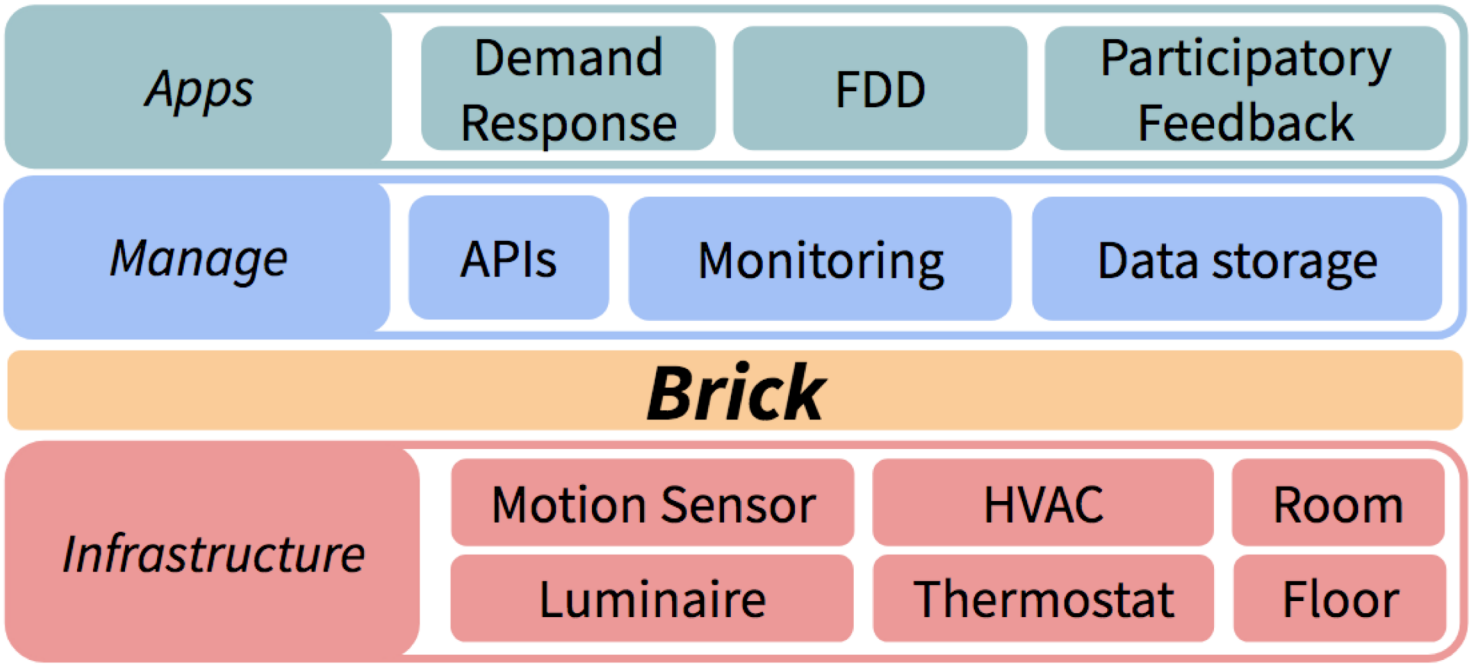
- Mappings and translations for control applications.
- Application-informed schema development, alignment, and standardization.
- Schema management tools.
- Partnerships and technology transfer.



Brick Schema + Structured Metadata

Complimentary BTO projects:

- BEDES
- BuildingSync
- Alfalfa/BOPTEST
- VOLTTRON
- Spawn
- Open Building Control (OBC)

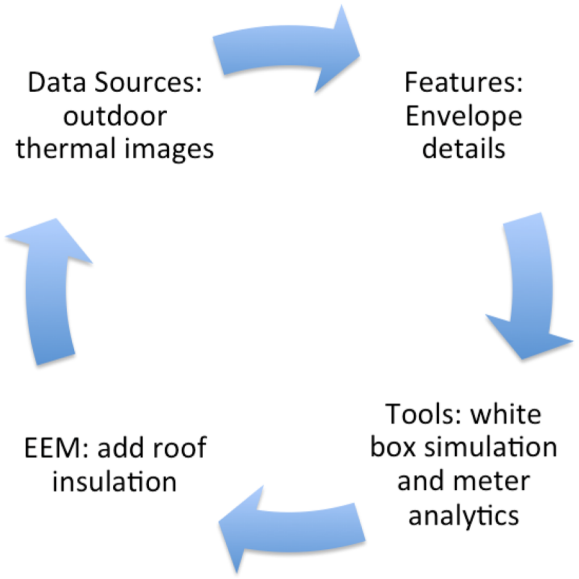


AirBEM

- **UAV-based envelope auditing procedure**
  - Goal: to be within 5% of an EnergyPlus model using current best practices for envelope heat/loss simulation.
  - Goal: reduce ASHRAE 211 detailed envelope inspection audit time by 60-75% (1-4 hours for 100k ft^2 building) and generate a BEM report in 1-3 days that shows retrofit opportunities that save 5-30% on monthly energy spend.
- **Approach**
  - Use off-the-shelf ready photogrammetry software to generate 3D surface and thermal models of buildings from geocoded visible and IR spectrum remote sensing technologies.
  - Computing contained on board UAV.

Unstructured Data

- **Develop automated approaches to determine building characteristics and efficiency opportunities using unstructured data from a subset of three categories:**
  - Public data – disclosure and permit records
  - Imagery – RGB (Red, Green, Blue), thermal and LIDAR (Light Detection and Ranging), acquired via satellite or aerial methods (airplanes or drones)
  - Meter and weather data
- **Opportunity Analysis: Which EEMs are identifiable from what data sources?**
  - Process: Map EEMs → Data Source → Feature → Tool



Summary & Review

Summary & Review

- **BTO's Role:** standardization, interoperability, provenance
- **Future:**
  - Automated data processing
  - Automated point-mapping with well managed metadata
  - Geospatial anchoring for indices via UBID
  - "Sliding scale" for spatial granularity of data & nested analyses across tools
    - i.e.: country → region → city → district → building → floor → room → system → endpoint
  - Heavy lifting for analysis, computing, etc. is private sector service

Discussion

Until 3:30

Thank You

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U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Appendix